State of Louisiana
Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2005 Operation, Maintenance, and Monitoring Report

for

La. Highway 384
Hydrologic Restoration

State Project Number CS-21
Priority Project List 2

June 2005
Cameron Parish

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2005 Operation, Maintenance, and Monitoring Report
for
La. Highway 384 Hydrologic Restoration (CS-21)

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Preface

The Operations, Maintenance, and Monitoring (OM&M) Report format is a streamlined approach which combines the Operations and Maintenance annual project inspection information with the Monitoring data and analyses on a project-specific basis. This report includes monitoring data collected through December 2004, and annual Maintenance Inspections through June 2005.

The 2005 report is the second in a series of reports. For additional information on lessons learned, recommendations, and project effectiveness, please refer to the 2004 Operations, Maintenance, and Monitoring Report on the Louisiana Department of Natural Resources (LDNR) web site dnr.louisiana.gov (Sharp and Billodeau 2007).

I. Introduction

The La. Highway 384 Hydrologic Restoration Project area contains 935 ac (378 ha) of deteriorated wetlands located along the northeast shoreline of Calcasieu Lake in Cameron Parish. The project area is bounded by Calcasieu Lake to the west, the Gulf Intracoastal Waterway (GIWW) to the east, and higher elevation prairie formations to the north and south.

The project area (figure 1) is divided into three Conservation Treatment Units (CTUs). CTU 1 extends from Calcasieu Lake easterly to the La. Highway 384 embankment and includes 250 ac (101 ha) of open water and brackish marsh. A shell oilfield access road forms its northern boundary and prairie formations form its southern boundary. CTU 2 includes 226 ac (91 ha) of open water and intermediate marsh. This unit extends easterly from the La. Highway 384 embankment. The northern boundary of CTU 2 is the prairie formation on which the community of Grand Lake is located. A continuous oilfield road embankment joins the prairie formations north and south of the project area and forms the remainder of the southern and eastern boundaries of CTU 2. CTU 3 lies between CTU 2 and the GIWW and includes 459 ac (186 ha) of intermediate marsh. Increased tidal volumes, enlargement of tidal exchange routes, and salt water intrusion resulting from human-induced changes to the area's hydrology are the primary causes of wetland loss in the project area.

Two small reference areas have been selected for monitoring this project. Reference Area 1 (R1) comprises 424 ac (172 ha) of deteriorated brackish marsh and open water located 2 mi (3.2 km) south of the community of Grand Lake along the east bank of Calcasieu Lake (figure 1). Reference Area 2 (R2) consists of approximately 106 ac (43 ha) of open water and deteriorated brackish marsh located along the north side of the shell road that forms the northern boundary of CTU 1.

The objective of the project is to protect and maintain approximately 935 ac (378 ha) of intermediate to brackish wetlands by reducing water level variability, thereby increasing the abundance of emergent vegetation. This will be achieved through structural modification of hydrologic conditions. Construction for the La. Highway 384 Hydrologic Restoration Project began on October 20, 1999, and was completed on January 4, 2000.

The principal project features include:

1. Set of three culverts (ES-1), each with a manual sluice gate on the exterior and a flap gate on the interior to provide controlled freshwater introduction from the GIWW (CTU 2/CTU 3 perimeter levee).

2. Approximately 95 ft (28 m) of armored plug (ES-8) to reduce hydrologic exchange with Calcasieu Lake and to decrease tidal scour and salinity in the project area (existing exchange point in CTU 1).

3. Set of two culverts (ES-12), each with a variable-crested weir inlet and flap gated outlet to reduce and stabilize tidal ranges and salinity in project area south of the central shell road in CTU 1 (existing shell road along north side of CTU 1).

4. Maintenance of approximately 10,000 ft (3 km) of existing road embankment to maintain the hydrologic barrier between CTU 2 and CTU 3 (existing southern and eastern perimeter embankment of CTU 2).

5. Maintenance of one flow-through culvert (ES-11) to maintain an existing storm water drainage point for the adjacent prairie formation (existing southern perimeter embankment of CTU 2).

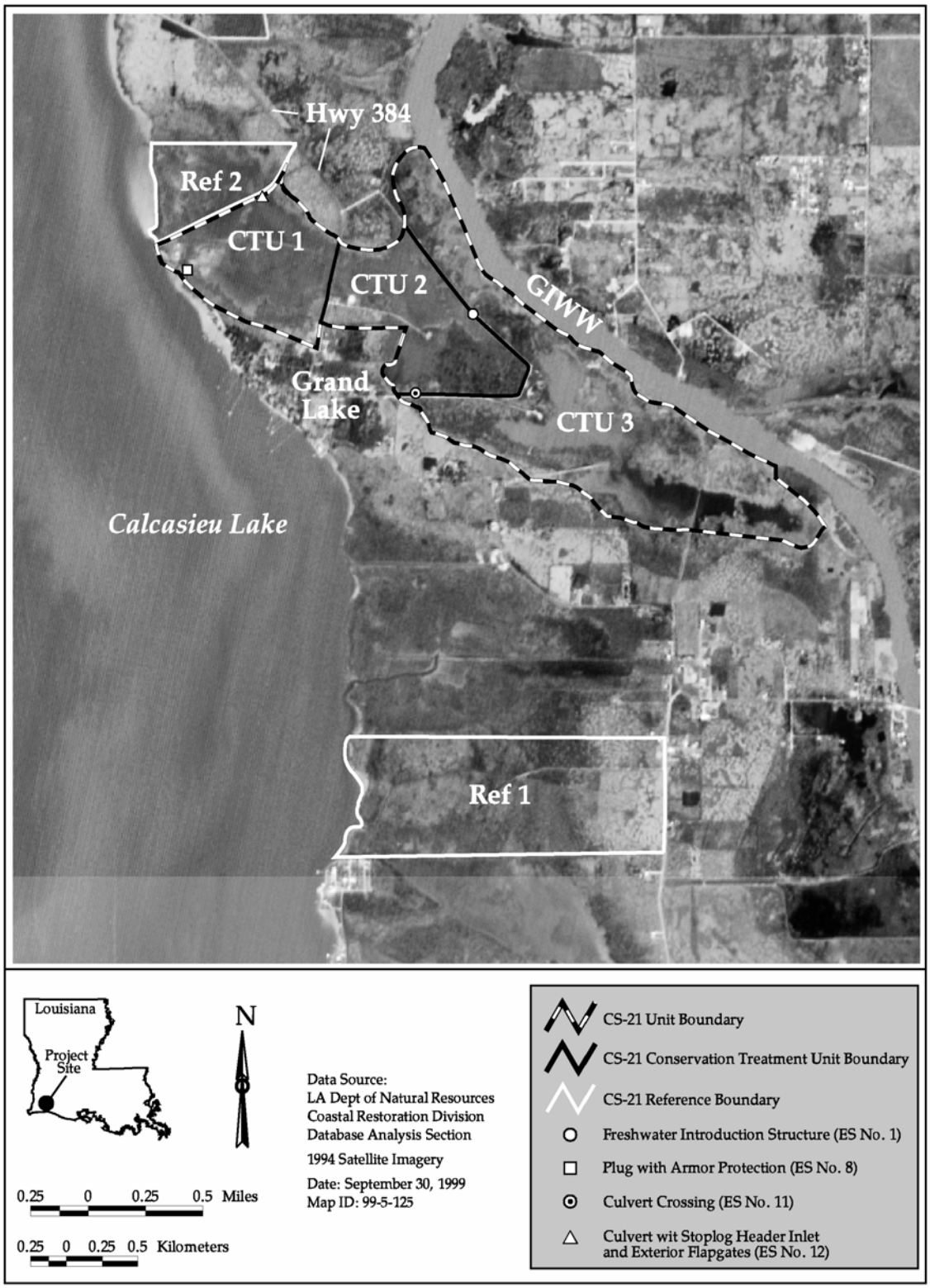


Figure 1. La. Highway 384 Hydrologic Restoration (CS-21) project and reference area boundaries and features.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the La. Highway 384 Hydrologic Restoration Project (CS-21) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, LDNR shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs.

An inspection team consisting of two representatives of LDNR and one representative of the Natural Resources Conservation Service (NRCS) performs annual visual inspections. If damage is apparent, LDNR and NRCS assign a team to perform a detailed inspection and report on the findings. The team documents the condition of the project features and may employ a survey party to make detailed measurements. As noted in Appendices A, B, and C, initial project goals included documenting inspections with photographs, creating a three-year budget projection, and taking field inspection notes.

b. Inspection Results

This project is currently under maintenance, and therefore no annual inspection was performed during 2005.

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

Replacement of the cap of the rock plug (Structure #8) that was vandalized was replaced in May 2005.

ii. Programmatic/ Routine Repairs

N/A

d. Maintenance History

Three separate maintenance projects have been completed since the original project's construction completion. Engineering and design as well as

construction oversight on all of these maintenance projects were provided by Abbeville/Lafayette field office personnel so no exact costs related to these activities are available. The maintenance projects that were performed were as follows:

Nov. 2000- Glenn Lege Construction

-Placed 40.32 cy. of #610 limestone on the road near Structure #12 due to some overtopping of the road during high tidal events.

-Placed 12 cy. of man-size rip-rap on the inlet side of Structure #12 due to some scouring of the bankline around the structure

TOTAL CONSTRUCTION COST- $3,461.14

June 2002- Glenn Lege Construction

-Provided labor and materials to construct a "hyacinth fence" on the inlet side of Structure #1. The fence is constructed of galvanized woven wire and chromated copper arsenate (CCA) treated timber piles and whalers.

-Provided labor and materials to reinforce the existing levee around Structure #1 with graded crushed stone.

-Provided labor and materials to repair an existing rock plug that had been leaking and also had been vandalized. The plug was repaired by hauling in earth fill from an off-site location and pushing it over the existing rock plug with a bulldozer. The earthen plug was then planted under separate contract by LDNR's plantings group.

TOTAL CONSTRUCTION COST- $14,386.87

May 2005- Bertucci Construction

Provided labor, material, and equipment to repair 13 linear feet (4 m) of the rock plug at site #8. The rock was removed by vandals. 39.9 tons of 1200# rip-rap stone was used to repair the 13-ft (4-m) gap. A 4-ft (1.2-m)-thick layer of 150# stone was applied to the marsh side slope of the plug to prevent water flow through the plug. This required 343.4 tons of rock. Completion and final acceptance was on May 15, 2005.

TOTAL CONSTRUCTION COST- $45,090.00

III. Operation Activity

a. Operation Plan

"WATER MANAGEMENT SCHEMES"

ES #1 Structure - 3-24" Aluminum culverts with Interior 24" Flapgates and Exterior 24" Sluice Gates.

	Culvert #1		Culvert #2		Culvert #3	
Water Level[1]	Sluice	Flap	Sluice	Flap	Sluice	Flap
< +0.2' ML[2]	open	down	open	down	open	down
> +0.2' ML	close	down	close	down	close	down

\1 - Average Water Level in CTU #2.

\2 - Average Marsh Level (approx. 1.1' msl).

NOTE: When salinities at ES #12 exceed 10 ppt, the ES #1 structure will be operated to allow maximum flow of freshwater into the project area. Normal structure operations are to resume when salinities fall below 10 ppt.

ES #12 Structure- 2-48" Aluminum Culverts, each w/ an Interior 10' Variable-Crested Weir Inlet with a 4" vertical slot and an Exterior 48" Flapgate.

	Culvert #1			Culvert #2		
Salinity*	Flap	Stoplog*	Slot	Flap	Stoplog	Slot
< 7 ppt	open	-24"	open	open	none	open
7 - 10ppt	down	-6"	open	open	none	open
> 10 ppt	down	-6"	open	down	-12"	open

* Salinity will be monitored on the northern side of the shell road at site #12.

* Stoplog elevations relative to average marsh level (approx. 1.1' msl). "None" refers to removal of all stoplogs.

b. Actual Operations

In accordance with the operation schedule outlined in the Operation and Maintenance Plan and U.S. Army Corps of Engineers (USACE) Permit, structures were manipulated as required by Simon & DeLany, Resource Management personnel who are under contract with LDNR. Copies of the quarterly reports that are provided as well as a copy of the operations contract between LDNR and Simon & DeLany are available in the "Structure Operations" section of the CS-21 La. Highway 384 Operation & Maintenance Plan. The only operation during the year was on October 29, 2004, when one stop log was removed from each of the four bays on structure ES 12. This action was taken due to high salinity. The contract with Simon and DeLany Resource Management, L.L.C. will be renewed for the coming year for the operation of the structures and data gathering. To view the real-time conditions at #1 or #12 Structures, log on to www.romcomm.net and use ldnr for both the username and pass word. 15r is for structure #12 and 29r for structure #1.

IV. Monitoring Activity

Pursuant to a Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Task Force decision on August 14, 2003, to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the CS-21 Monitoring Plan to merge it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning, while maintaining the monitoring mandates of the Breaux Act.

a. Monitoring Goals

The objective of the La. Highway 384 Hydrologic Restoration Project is to protect and maintain 935 ac (378 ha) of intermediate and brackish wetlands by reducing water level variability, thereby increasing the abundance of emergent vegetation.

The following goals will contribute to the evaluation of the above objective:

1. Decrease the rate of marsh loss in the project area.
2. Reduce water level variability within the project area.
3. Maintain salinity levels within CTU 1 at ≤ 10 ppt.
4. Maintain salinity levels in CTU 2 and CTU 3 within the 0-5 ppt target range for intermediate marsh vegetation.
5. Increase the coverage of emergent wetland vegetation and submerged aquatic vegetation (SAV) in shallow open water areas within the project area.

b. Monitoring Elements

Habitat Mapping

Near-vertical, color-infrared aerial photography (1:12,000 scale, with ground controls) was used to measure vegetated and non-vegetated areas for the project and reference areas. The photography was obtained pre-construction for the project area and reference area 2 (R2) in December 1996 and again in January 1997 due to overexposed frames. In March 1997, R1 was flown. Post-construction photography was obtained December 15, 2002. The original photography was checked for flight accuracy, color correctness, and clarity, and was subsequently archived. Aerial photography was scanned, mosaicked, and georectified by U.S. Geological Survey/National Wetlands Research Center (USGS/ NWRC) personnel according to the standard operating procedures (Steyer et al. 1995, revised 2000). No additional photography is scheduled.

Salinity

Water salinity was monitored monthly at 29 discrete sampling stations within the project and reference areas and at four continuous recorders in each of the

project areas (CTUs 1-3) and reference areas R1 and R2 (figure 2). The recorders were deployed in May 1997 to log hourly salinity. Salinity data were collected at all four stations until July 2004.

Water Level

Water level was monitored monthly at the same discrete sampling stations as salinity and at staff gauges installed inside and outside of the project area near the two CS-21 project water control structures. The four continuous data recorders that were deployed in May 1997 to recorded hourly water level in the three project areas and in R1. These data are available in raw and graphic formats. To document the frequency, magnitude, and duration of head differences conducive to freshwater introduction into the project from the GIWW, the data recorders in CTUs 2 and 3 were deployed near the freshwater introduction structure, one on each side of the structure (figure 2). All four recorders were surveyed to NAVD 88. Water level data were collected until July 2004.

Emergent Vegetation

Vegetation was monitored at a maximum of 30 sampling stations established uniformly along transects in the project and reference areas (CTU 1, CTU 2, CTU 3, R1, and R2). At each sampling station, percent cover, species composition, and dominant plant height were documented in a 2-m x 2-m sampling plot marked with a pole in the southeast corner of the plot to allow for revisiting each site over time. Vegetation was evaluated at the sampling sites pre-construction in 1997, and post-construction in 2002. No additional vegetation sampling is scheduled.

Submerged Aquatic Vegetation (SAV)

SAV was monitored using the modified rake method (Chabreck & Hoffpauir 1962; Nyman and Chabreck 1996). Within each study area (CTU 1, CTU 2, CTU 3, and R2), two ponds were sampled for presence or absence of SAV at 25 random points within each pond. Species composition and frequency of occurrence [freq = (n occurrences SAV species / n total sampling points)*100] were determined. SAV was monitored once pre-construction, in October 1996, and once post-construction, in September 2002.

Soil Characteristics

Soil samples were collected from the emergent vegetation sampling plots established in the project and reference areas and analyzed for bulk density, percent organic matter, and soil salinity. Soil samples collected pre-construction in 1997 were not collected post-construction.

c. Preliminary Monitoring Results and Discussion

Habitat Mapping

Photography of the project area was obtained by USGS in 1997 and 2002 (figures 3 and 4). The two flights showed a modest increase in the percentage of each area that can be considered land (table 1, figure 5). The greatest increase in land was in CTU 3, where there was an increase of 4.2%. The total increase for the project areas combined was 3.4%, while the reference areas collectively increased by 1.7%. Percent land increased in both the project and reference areas. The increases were small in both the project and reference areas, although they were larger in the project areas. The 1997 percent land was subtracted from the 2002 percent land for each unit, and project units were compared to reference units with a t-test. The test revealed that there was no significant difference between the project and reference in percent land increase ($F_{1, 4}$=3.79, p=0.1469).

Salinity and Water Level

Hourly salinity and water level data have been collected at the following continuous recorder stations:

Station	Period of data collection
CS21-19 (CTU 1)	January 1997 – June 15, 2004
CS21-26 (CTU 2)	January 1997 – January 2002
CS21-98 (CTU 2)	January 2002 – July 28, 2004
CS21-29 (CTU 3)	January 1997 – July 28, 2004
CS21-07R (R1)	January 1997 – July 28, 2004

Due to low water levels, the recorder at CS21-26 was no longer able to function properly and was replaced by CS21-98 and moved approximately 100 yards north.

Water level and salinity data from January 1, 2004, to June and July, 2004, at all four stations are presented below (figures 6 and 7). Mean monthly salinity data reveal that salinity was highest in the reference area throughout the year and that mean salinities were within the target range for salinity each month (≤10 ppt CTU 1, ≤ 5 ppt CTUs 2 and 3) (figure 8). Mean monthly water levels were below the marsh surface in the project area from January to April 2004. The marsh in the project areas was flooded during the early summer in May and June 2004 (figure 9).

An in-depth analysis of salinities and water levels relative to the target levels for each hydrologic unit pre- and post-construction was conducted and is presented in the 2004 OM&M report (Sharp and Billodeau 2007).

Submerged Aquatic Vegetation

The project goal for SAV was to increase frequency of occurrence of SAV in the three project areas relative to the SAV reference unit, R2. SAV was sampled twice pre-construction (1996 and 1997) and once post-construction. There was little cover in any unit in 1996 except for CTU 3, which had 11 species present and nearly 100% cover, and a small amount of algae in CTU 1 (table 2, figure 10). 1997 saw near-total cover in CTU 3 with nine species present, 79% algae in CTU 2, and 5% more algae in CTU 1. Post-construction in 2002, cover had increased to 66% in CTU 1, all of it being *Ruppia maritima* (widgeongrass). Cover remained high in CTU 2 and SAV switched from mostly algae to being dominated by *Ruppia maritima*. Cover remained near 100% in CTU 3 with 10 species present. The reference area (R2) had nearly 34% cover in 2002, mostly *Ruppia maritima*.

Statistical comparisons were made for all of the project units relative to the reference unit pre- and post-construction, with the data from 1996 and 1997 being pre-construction and the data from 2002 being post-construction. Collectively, there was no difference between project and reference units pre- and post-construction ($F_{1,\ 1}$=0.0307, p=0.8627). Individual comparisons were made of each project unit to the reference unit pre- and post-construction. Those tests revealed that CTU 1 and R2 were not significantly different from each other ($F_{1,\ 1}$=1.691, p=0.2296). Frequency of occurrence increased in both the project and reference areas from 0% to 34% in R2 and from 5% to 67% in CTU 1. However, the standard error for each unit post-construction was 12%, which made the difference insignificant. The high standard error was due to the fact that the two transects in CTU 3 were so different post-construction, with one transect having 100% cover and the other having 33% cover. CTU 2 was not significantly different from R2 either ($F_{1,\ 1}$=0.1705, p=0.6968). Frequency pre-construction was near zero in R2 and 37% in CTU 2. Post-construction, cover increased in both units, to 34% in R2 and to 86% in CTU 2. The magnitude of the change was statistically the same in each unit, so differences were not statistically different. CTU 3 was significantly different from R2 pre- and post-construction ($F_{1,\ 1}$=46.083, p<0.0001). The difference in CTU 3 and R2 was due to the fact that cover remained near 100% in CTU 3 while it increased from near zero to 34% in R2. Frequency of occurrence of SAV increased in all areas post-construction and, although the total cover of SAV was higher in the project units, the increase in SAV in R2 over the course of the project caused increases in project units to be statistically insignificant. It is likely that SAV in the entire project responds more to yearly weather and salinity trends than to the CS-21 project itself. Or, if the differences in SAV are project effects, perhaps the reference area is impacted by the project also. CTU 3 has had lower salinities throughout the life of the project (figure 11).

Emergent Vegetation

The project goal for emergent vegetation was to increase cover in shallow open water areas within the project area. This goal specifically refers to increasing cover of intermediate marsh in CTU 2, maintaining intermediate conditions in CTU 3, and increasing cover of brackish marsh in CTU 1. According to surveys performed pre-construction in 1997, CTU 1 was primarily dominated by *Juncus roemerianus* (needlegrass rush), with some *Spartina patens* (marshhay cordgrass) and some more-saline species present, including *Spartina alterniflora* (smooth cordgrass) and *Distichlis spicata* (seashore saltgrass). The 2002 survey showed an increase in *Spartina patens* and the presence of *Schoenoplectus robustus* (sturdy bulrush). Total percent cover increased post-construction from 58.8 % to 91.3% (figure 12).

Pre-construction in 1997, CTU 2 was dominated by *Spartina patens, Juncus roemerianis,* and *Eleocharis albida*. In 2002, several more species were present, including *Paspalum vaginatum* (seashore Paspalum) and other intermediate marsh species. The 2002 survey revealed that total percent cover had remained the same (73%) (figure 12), while species richness increased from 4.8 to 8.3 species per plot. The additional species and the decrease in the cover of common brackish species suggest CTU 2 is also on target for intermediate vegetation goals.

CTU 3 was dominated by *Spartina patens, Schoenoplectus californicus* (California bulrush), and *Sagittaria lancifolia* (bulltongue) in 1997. By 2002, the unit was dominated by *Spartina patens, Typha latifolia* (cattail), and *Juncus roemerianus,* species richness had increased from 6.6 to 10.5 species per plot, and total cover had increased from 59% to 79% (figure 12). These results are consistent with the project goals of increasing the cover of intermediate marsh.

Reference areas 1 and 2 showed little change from 1997 to 2002, being dominated by *Juncus* and *Spartina patens. Spartina alterniflora* began to emerge and *Distichlis spicata* decreased post-construction in R1. Total cover increased in both units (figure 12), and species richness slightly decreased in R2 from 3.3 to 2.7 species per plot.

Soil Characteristics

Soil characteristics were originally collected in 1997. Soil characteristics are consistent with brackish type marshes (table 3) (Palmisano 1972).

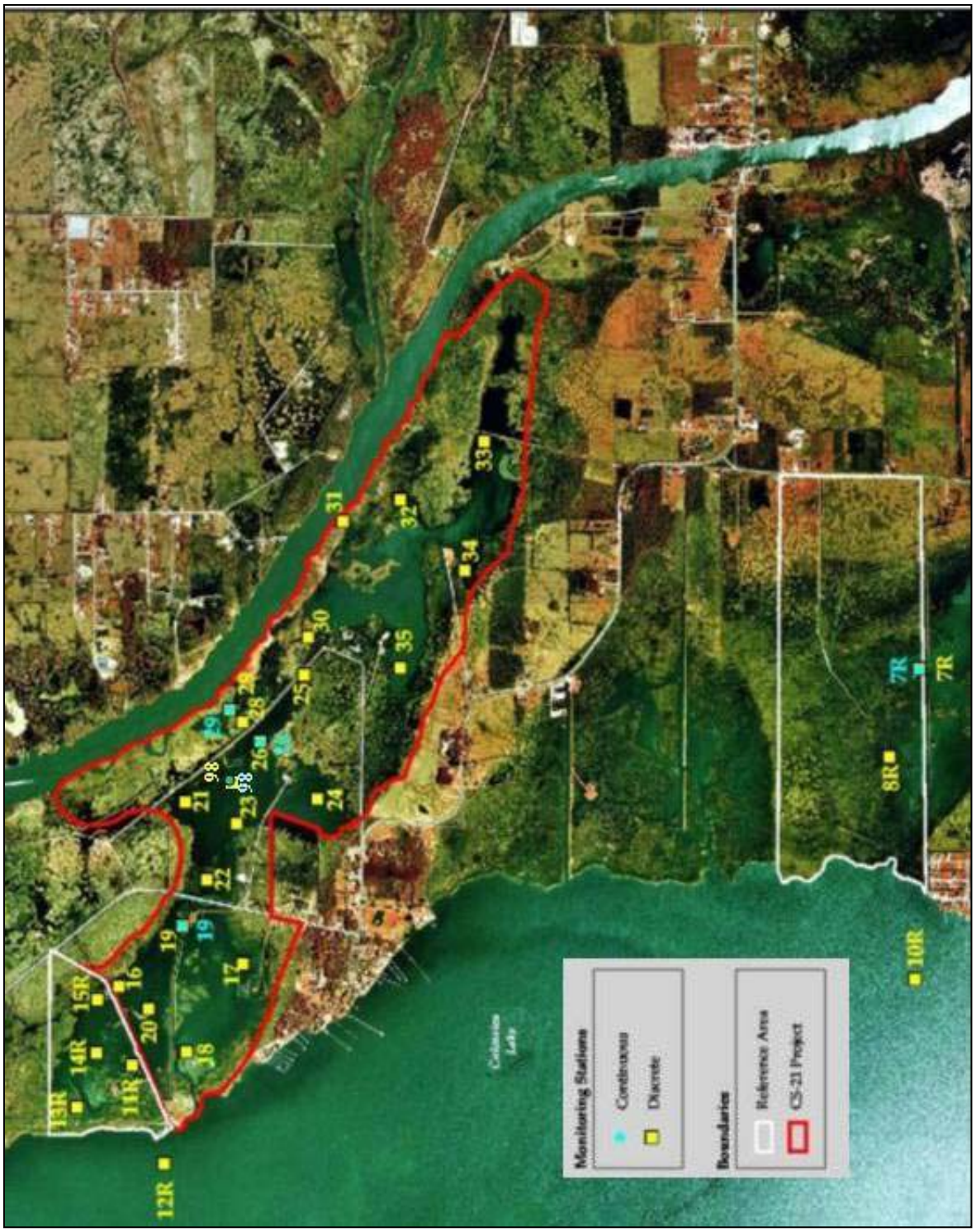


Figure 2. Location of continuous recorders and discrete water quality stations for La. Highway 384 Hydrologic Restoration (CS-21).

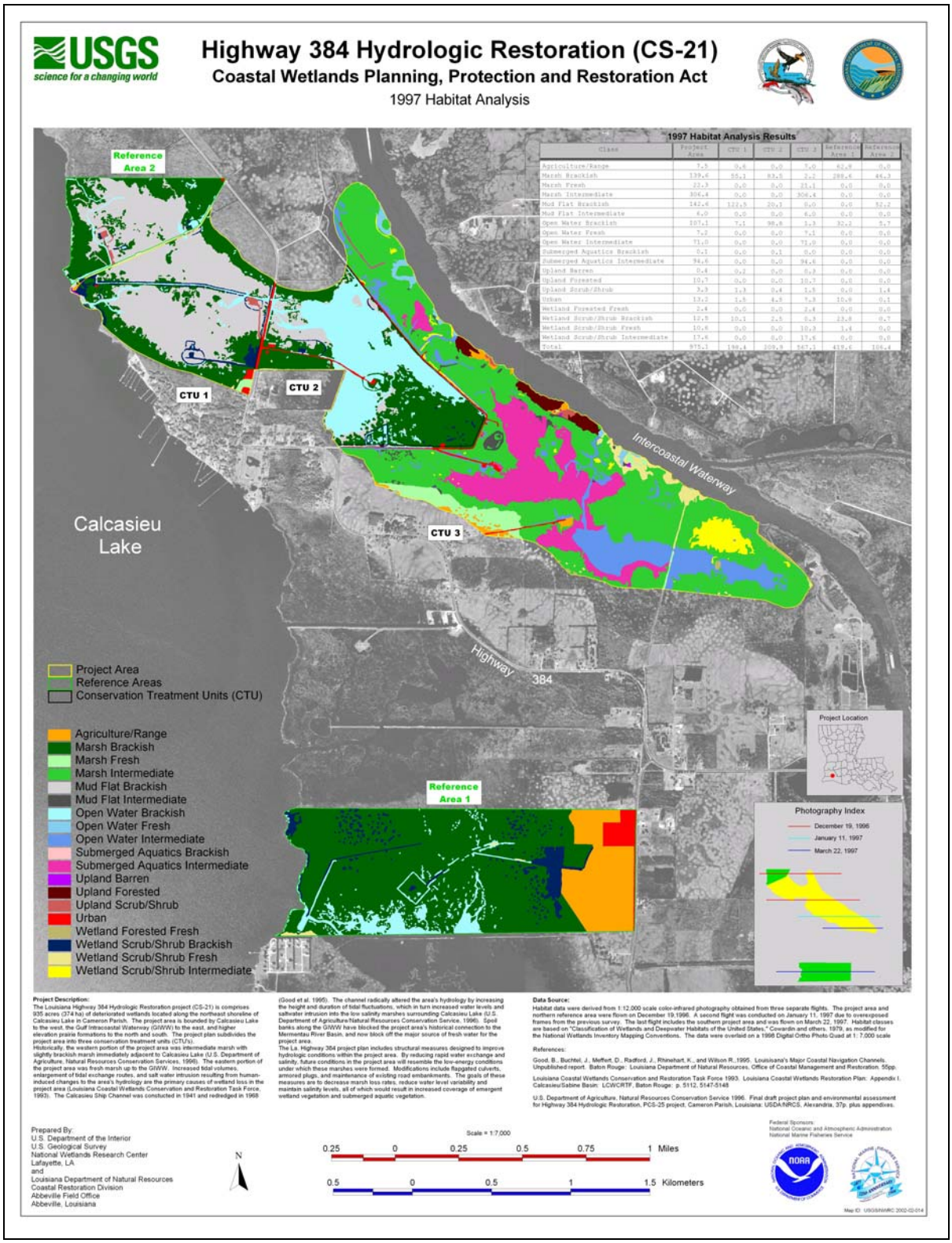


Figure 3. Habitat analysis from aerial photography flown January 11 and March 22, 1997.

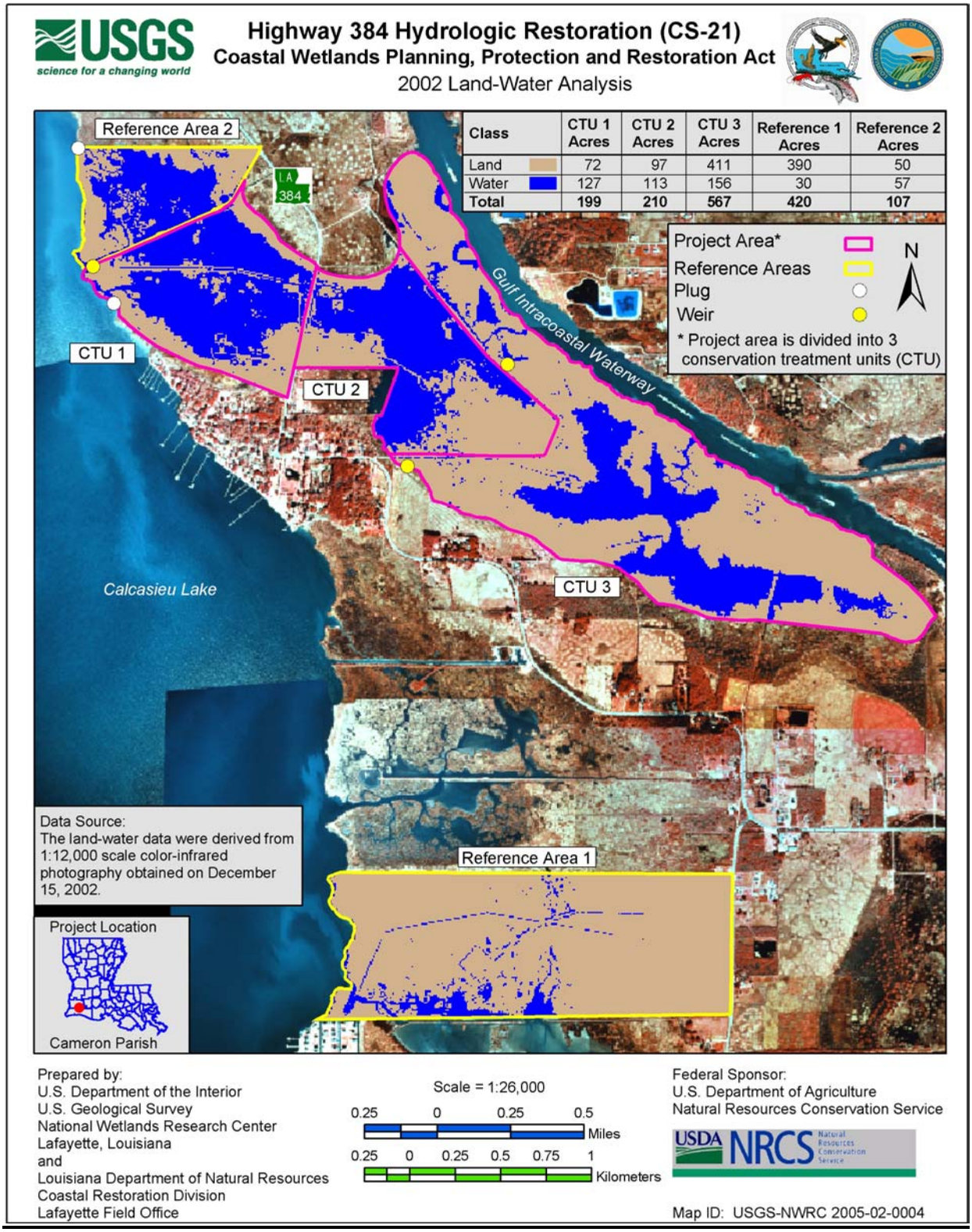


Figure 4. Land to water analysis from aerial photography flown December 15, 2002.

Table 1. Area and ratios of land and water for the La. Highway 384 Hydrologic Restoration (CS-21) Project from aerial photography obtained pre-construction in 1997 and post-construction in 2002. The 1997 photography was classified by habitat (figure 3), while the 2002 photography was just classified by land and water (figure 4), so acreages of land were summed. Mudflats were considered water and upland habitats were included. Total acreages from the two years are not exactly the same so percentages and differences in percentages should be used for comparison.

	Total Project		CTU 1		CTU 2		CTU 3		Total Reference		R1		R2	
	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha
1997 Land	546.5	221.2	68.8	27.8	90.9	36.8	387.1	156.7	430.2	174.1	387.4	156.8	48.5	19
1997 Water	428.6	173.4	129.6	52.4	119.0	48.2	180.0	72.8	95.8	38.8	32.2	13.0	57.9	23
2002 Land	580.0	234.7	72.0	29.1	97.0	39.3	411.0	166.3	440.0	178.1	390.0	157.8	50.0	20
2002 Water	396.0	160.3	127.0	51.4	113.0	45.7	156.0	63.1	87.0	35.2	30.0	12.1	57.0	23
1997 Land %	56.0		34.7		43.3		68.3		81.8		92.3		45.6	
1997 Water %	44.0		65.3		56.7		31.7		18.2		7.7		54.4	
2002 Land %	59.4		36.2		46.2		72.5		83.5		92.9		46.7	
2002 Water %	40.6		63.8		53.8		27.5		16.5		7.1		53.3	
1997 TOTAL	975.1	394.6	198.4	80.3	209.9	84.9	567.1	229.5	526.0	212.9	419.6	169.8	106.4	43
2002 TOTAL	976.0	395.0	199.0	80.5	210.0	85.0	567.0	229.5	527.0	213.3	420.0	170.0	107.0	43
2002-1997 Land %	3.4		1.5		2.9		4.2		1.7		0.5		1.1	

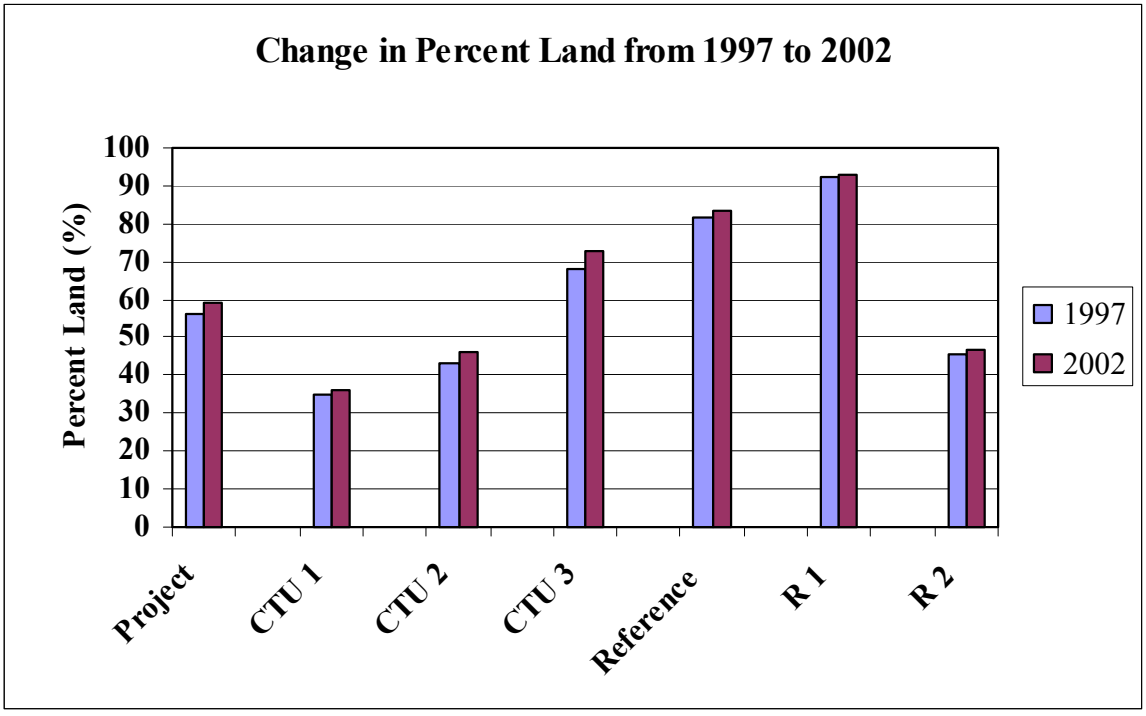


Figure 5. Percent of land area in 1997 and 2002 from aerial photography of each project CTU and the reference areas.

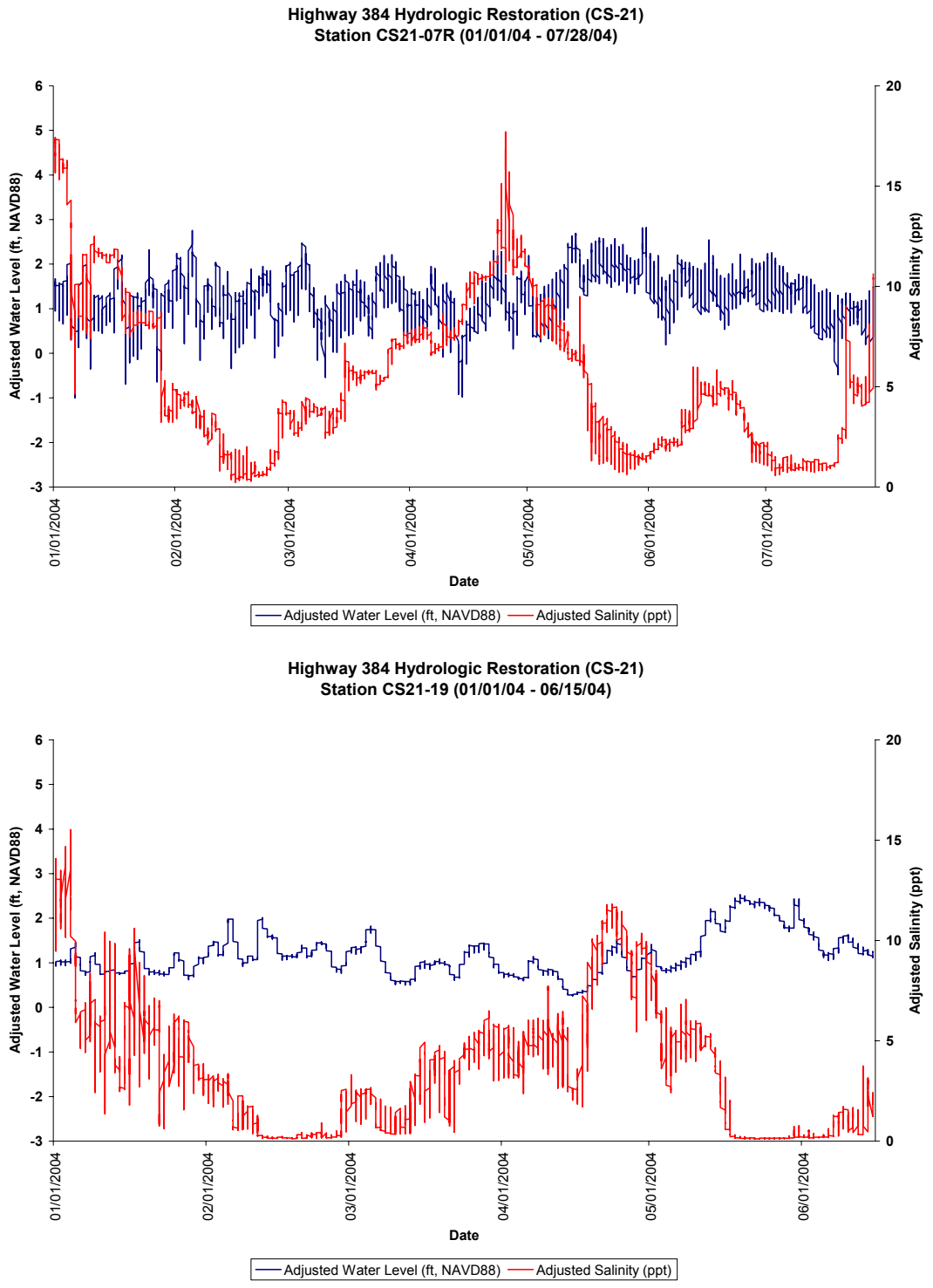
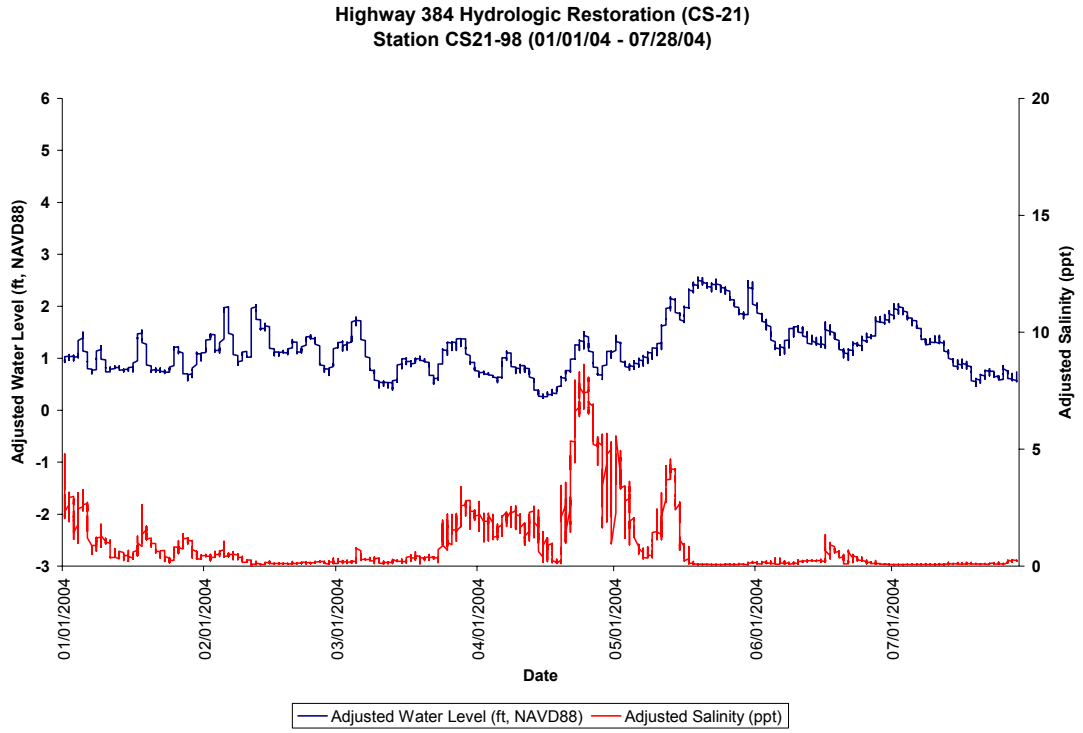


Figure 6. Water level and salinity data from stations CS21-7R (top) and CS21-19 (bottom), shown in feet.



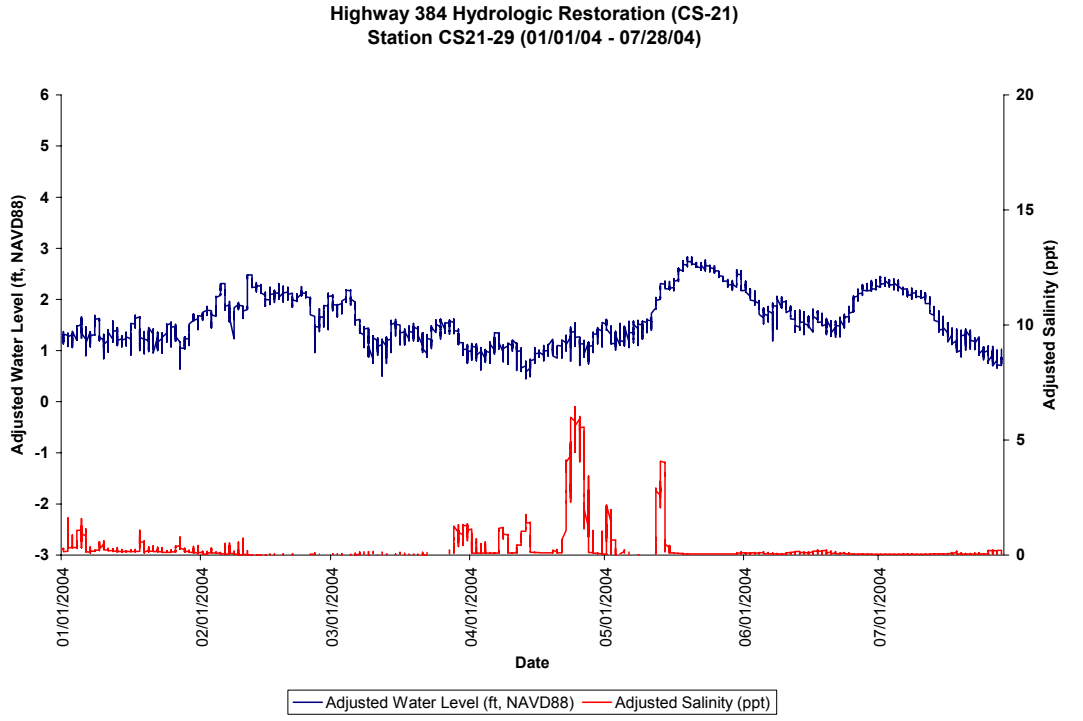


Figure 7. Water level and salinity data from stations CS21-98 (top) and CS21-29 (bottom), shown in feet.

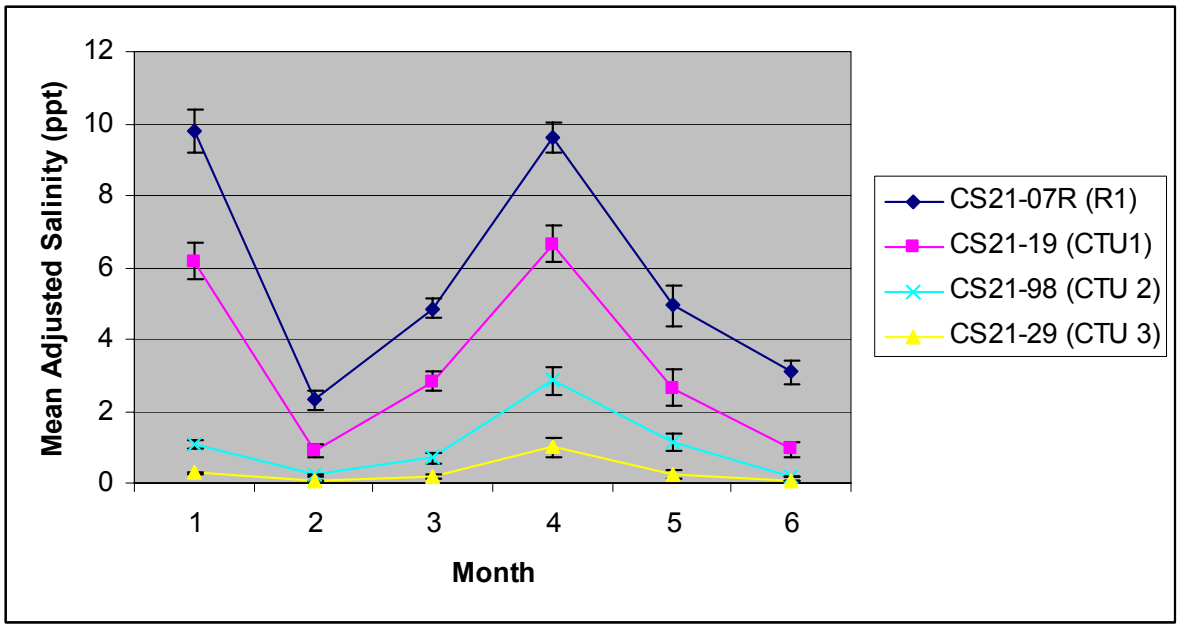


Figure 8. Monthly mean (of daily means ± Standard Error) of salinity from January to June, 2004 in the CS-21 project and reference areas.

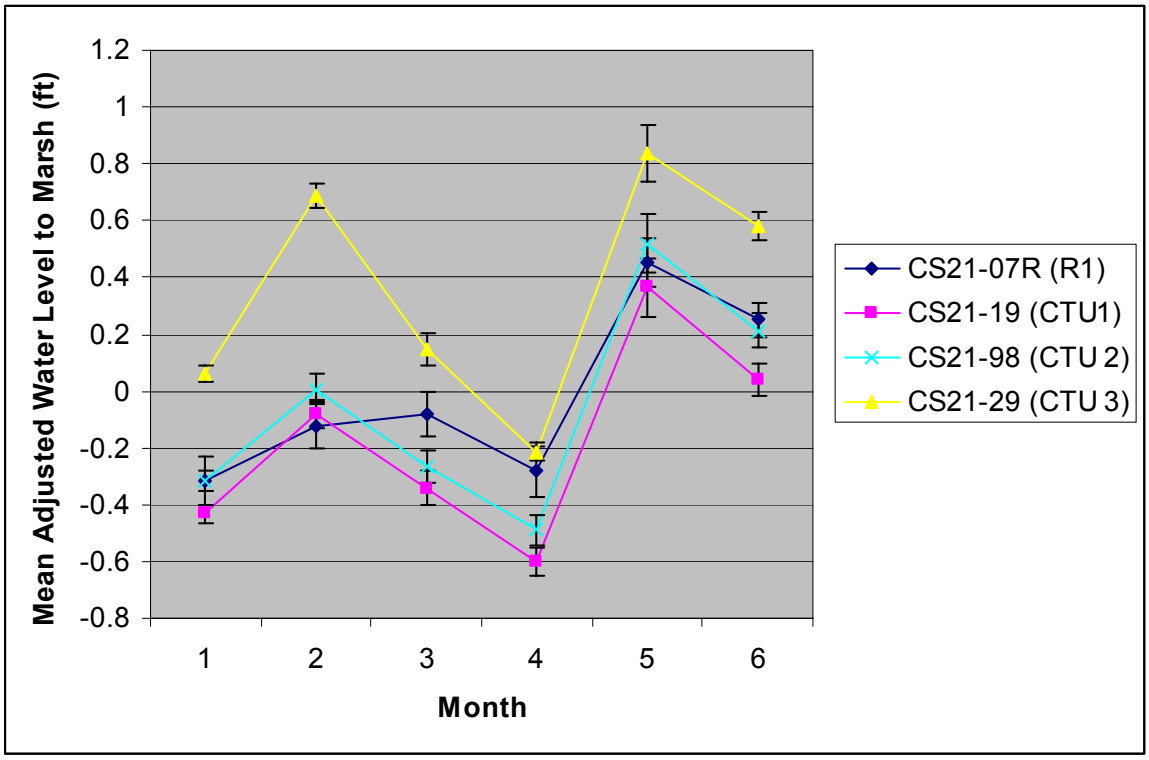


Figure 9. Monthly mean (of daily means ± Standard Error) of water level relative to marsh elevation from January to June, 2004, in the CS-21 project and reference areas.

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Table 2. Frequency of occurrence of SAV species in the project area and reference area R1.

	CTU 1			CTU 2			CTU 3			R	
SAV Species	**1996**	**1997**	**2002**	**1996**	**1997**	**2002**	**1996**	**1997**	**2002**	**1996**	**19**
none	97.50	92.79	34.38	100.00	19.05	11.76	0.72	.	1.90	99.17	100
Alga	2.50	7.21	.	.	79.37	15.69	23.55	10.92	.	.	
Alternanthera philoxeroides	.	.	.	.	.	.	.	.	0.95	.	
Cabomba caroliniana	.	.	.	.	.	.	.	0.34	.	.	
Ceratophyllum demersum	.	.	.	.	.	.	3.99	2.05	4.29	.	
Chara sp.	.	.	.	.	.	.	6.52	8.87	36.19	.	
Eleocharis parvula	.	.	.	.	.	.	8.33	15.02	2.86	.	
Elodea canadensis	.	.	.	.	.	.	.	.	1.43	.	
Myriophyllum spicatum	.	.	.	.	.	.	3.26	4.10	30.48	.	
Najas guadalupensis	.	.	.	.	.	.	18.12	16.04	10.48	.	
Nelumbo lutea	.	.	.	.	.	.	0.36	.	.	.	
Nymphaea sp.	.	.	.	.	.	.	.	.	0.48	.	
Potamogeton pusillus	.	.	.	.	.	.	0.72	.	.	.	
Ruppia maritima	.	.	65.63	.	1.59	72.55	27.54	29.01	1.90	0.83	
Utricularia foliosa	.	.	.	.	.	.	0.36	.	.	.	
Vallisneria americana	.	.	.	.	.	.	6.52	13.65	9.05	.	

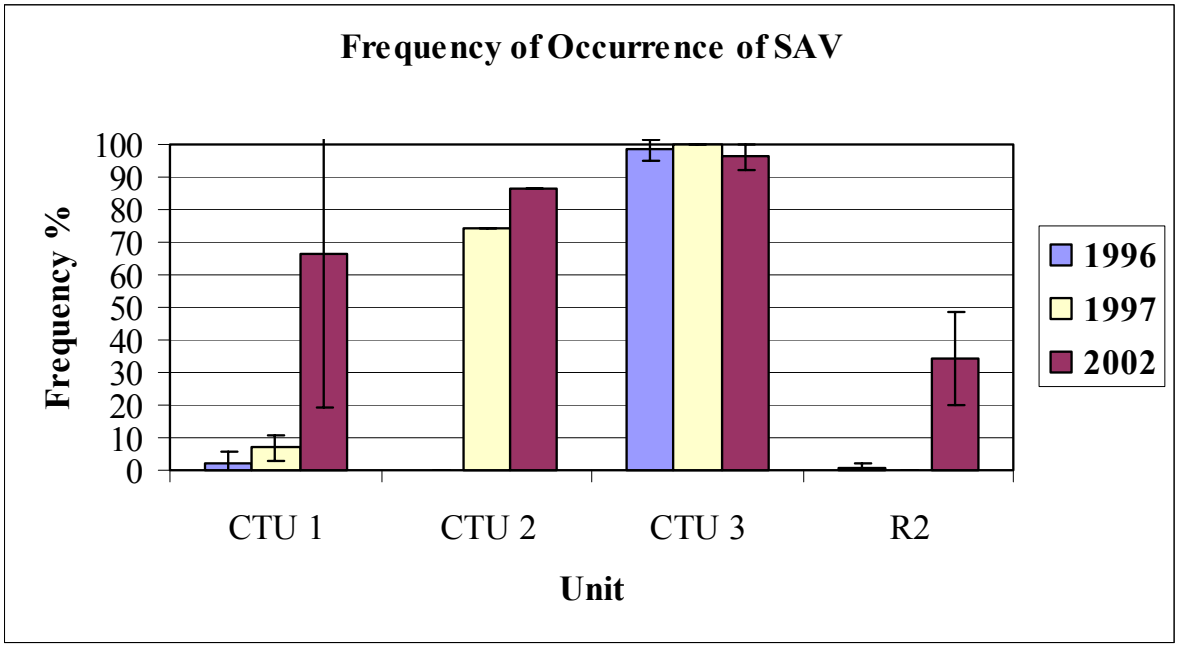

Figure 10. Total % cover of SAV species in the CS-21 project and reference area R2 for sampling years.

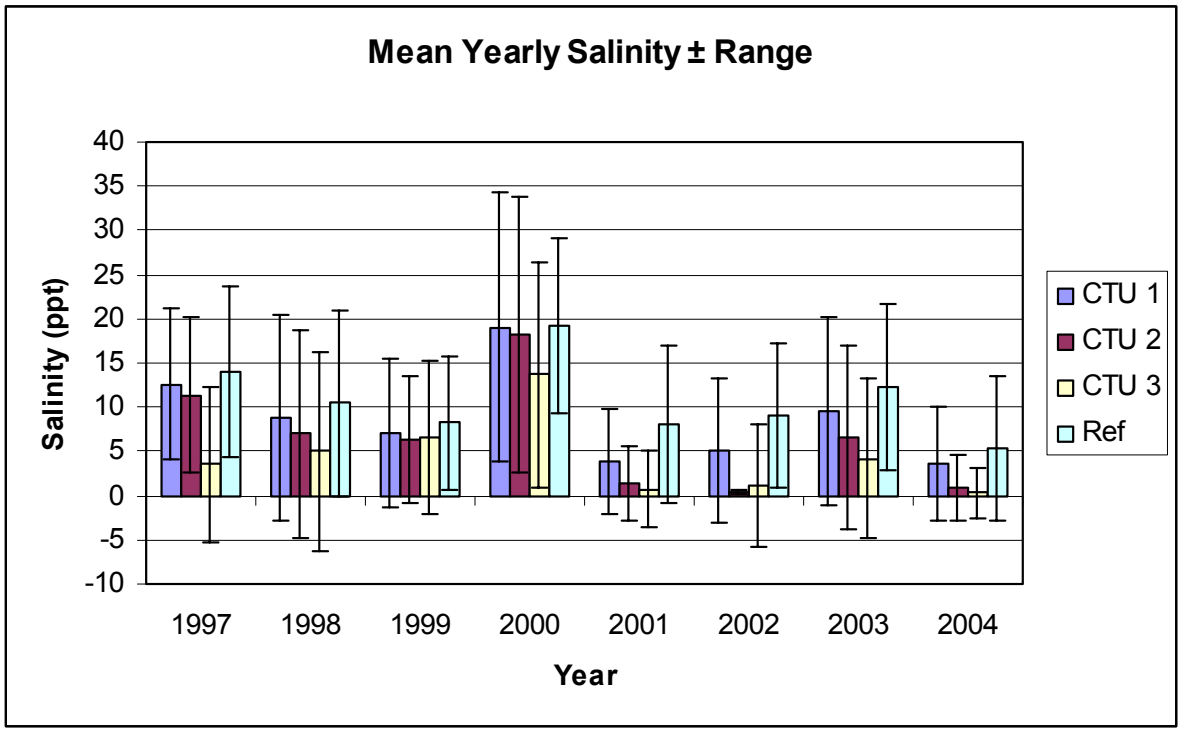

Figure 11. Mean salinity for each year the data sondes were deployed. All data were included even when data were missing from one sonde but not another. Error bars represent range of data for that year.

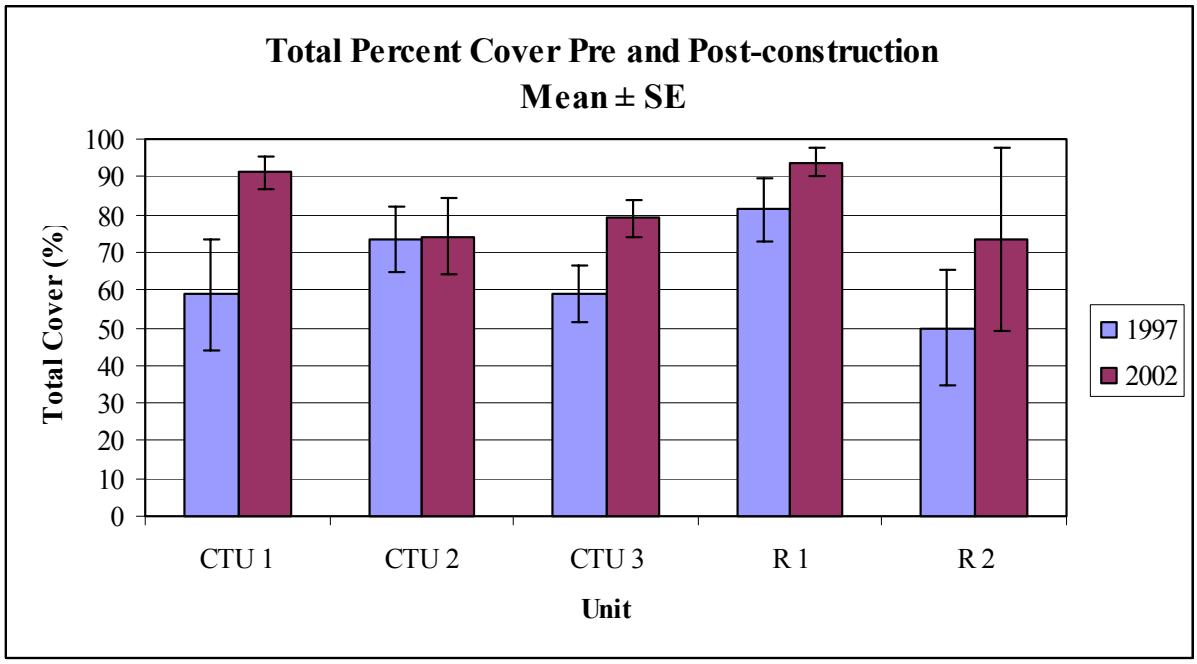

Figure 12. Total % cover in vegetation plots at the CS-21 La. Highway 384 Project pre- and post-construction, in 1997 and 2002, respectively.

Table 3. Pre-construction (1997) soil characteristic data for La. Highway 384 Hydrologic Restoration (CS-21) project and reference areas.

Unit	Percent (%) Organic Matter (%)	Bulk Density (oven) (g/cm^3)	Percent (%) Water (Moisture) (%)	Pore Water Salinity (ppt)	Organic Matter Density (oven) (g/cm^3)	Mineral Matter Density (oven) (g/cm^3)
CTU 1	0.20	0.68	0.72	17.65	0.13	0.54
CTU 2	0.21	0.70	0.71	18.32	0.12	0.58
CTU 3	0.12	0.85	0.49	12.63	0.09	0.75
R 1	0.26	0.49	0.75	18.53	0.12	0.37
R 2	0.11	0.81	0.63	17.10	0.39	0.72

V. Conclusions

a. Project Effectiveness

Land to water ratios in the project and reference areas pre- and post-construction did not change significantly (figure 5). Both project and reference areas maintained or made slight increases in land area.

Salinities in the project area were within the target range during the months that data was collected in 2004 (figure 8). Water levels were below the marsh surface in all of the project areas until May 2004, when they increased to around 0.4 ft above the marsh surface. Water levels in the reference area were above the marsh surface for most of the period measured (figure 9).

Cover of SAV increased in CTU 1 and in R2 post-construction. It reached nearly 80% in CTU 2 before construction and maintained that level post-construction. Cover remained near 100% in CTU 3 before and after construction (figure 10, table 2). This response was statistically insignificant. SAV dynamics do not appear to be affected by the project.

Total percent cover of emergent vegetation increased in all of the project and reference areas, most noticeably in CTU 1, CTU 3, and the reference areas (figure 12). Species richness increased in the two intermediate project areas (CTU 2 and CTU 3). The increases in cover and richness can most likely be attributed to the maintenance of salinity within the target ranges and the reduced water level range.

The monitoring plan stipulated that data collection should be discontinued if the project were functioning as designed. The data indicate that the structures are effective in meeting the project goals of reducing water level variability and increasing emergent marsh vegetation. Therefore, no additional monitoring will be conducted.

b. Recommended Improvements:

The structures have proven effective in achieving the goals of the project except during extreme weather conditions such as the drought in 2000. A revision to the permitted structure operations is recommended to provide increased control, restricting high salinity water from entering the project area from the GIWW, particularly at CTUs 1 and 2. This revision is also designed to increase the flow of freshwater into CTUs 1 and 2 when freshwater is available.

c. Lessons Learned:

No salinity data was available for the GIWW during the design phase of this project. It was assumed that the Calcasieu Locks prevented high-salinity water from entering the GIWW from Calcasieu Lake. Data gathered since construction of the project proved this assumption to be erroneous. CTU 3, the intermediate marsh adjacent to the GIWW, is particularly vulnerable to elevated salinity flow from the GIWW, as no provisions were made to restrict this flow through this portion of the project area. Future designs should be based on actual information, if available, gathered at specific locations.

If rock is to be used as a plug, the gradation shall be such that there will be no water flow through the plug. An earthen cover on a rock dike located adjacent to a large open water area such as Calcasieu Lake will be short-lived.

VI. REFERENCES

Chabreck, R. H. and C. M. Hoffpauir 1962. The use of weirs in coastal marsh management in coastal Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 16:103-12.

Nyman, J. A. and R. H. Chabreck 1996. Some effects of 30 years of weir management on coastal marsh aquatic vegetation and implications to waterfowl management. Gulf of Mexico Science 14:16-25.

Palmisano, A.W. 1972. Habitat preference of waterfowl and fur animals in the northern gulf coast marshes. Pages 163-190 in R.H. Chabreck, ed. Proceedings: Second Coastal Marsh Estuary Management Symposium, Louisiana State University, Baton Rouge.

Sharp, Leigh Anne and D. Billodeau 2007. 2004 Operations, maintenance and monitoring report for La. Highway 384 hydrologic restoration project (CS-21). Louisiana Department of Natural Resources, Coastal Restoration Division and Coastal Engineering Division.

Steyer, G. D., R. C. Raynie, D. L. Steller, D. Fuller, and E. Swenson 1995 (Revised June 2000). Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file series no. 95–01 Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 97 pp.

Appendix A
(Inspection Photographs)

No inspection was conducted in calendar year 2005 because this project is currently under a maintenance event, therefore no photographs were available.

Appendix B

(Three-Year Budget Projection)

LA Highway 384 Hydrologic Restoration / CS-21 / PPL2

Three-Year Operations & Maintenance Budgets 07/01/2005 - 06/30/08

Project Manager	O & M Manager	Federal Sponsor	Prepared By
	Dewey Billodeau	*NRCS*	*Dewey Billodeau*

	2005/2006	2006/2007	2007/2008
Maintenance Inspection	$ 4,955.00	$ 5,119.00	$ 5,288.00
Structure Operation	$ 6,000.00	$ 6,000.00	$ 6,000.00
Administration	$ 3,000.00	$ 4,000.00	$ 1,000.00
Maintenance/Rehabilitation			

04/05 Description

E&D	$ 19,547.00	
Construction	$ 45,090.00	
Construction Oversight	$ -	
Sub Total - Maint. And Rehab.	$ 64,637.00	

05/06 Description

E&D		$ -	
Construction		$ 50,000.00	
Construction Oversight		$ 7,168.00	
	Sub Total - Maint. And Rehab.	$ 57,168.00	

06/07 Description

E&D			$ -
Construction			$ -
Construction Oversight			$ -
	Sub Total - Maint. And Rehab.		$ -

	2004/2005	2005/2006	2006/2007
Total O&M Budgets	**$ 78,592.00**	**$ 72,287.00**	**$ 12,288.00**

OPERATION AND MAINTENANCE BUDGET 07/01/2005 - 06/30/20006

Highway 384 Hydrologic Restoration / CS-21 / PPL 2

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$4,955.00	**$4,955.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$19,547.00	**$19,547.00**
Operations Contract	LUMP	1	$6,000.00	**$6,000.00**
Construction Oversight	LUMP	1		**$0.00**
ADMINISTRATION				
LDNR / CRD Admin.	LUMP	1	$2,000.00	$2,000.00
FEDERAL SPONSER Admin.	LUMP	1	$1,000.00	$1,000.00
SURVEY Admin.	LUMP	1		$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$3,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
	Secondary Monument	EACH	0	$0.00	$0.00
	Staff Gauge / Recorders	EACH	0	$0.00	$0.00
	Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
	TBM Installation	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:						
	Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
	Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
	Navagation Aid		EACH	0	$0.00	$0.00
	Signage		EACH	0	$0.00	$0.00
	General Excavation / Fill		CU YD	0	$0.00	$0.00
	Dredging		CU YD	0	$0.00	$0.00
	Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
	Timber Piles (each or lump sum)			0	$0.00	$0.00
	Timber Members (each or lump sum)			0	$0.00	$0.00
	Hardware		LUMP	1	$0.00	$0.00
	Materials		LUMP	1	$0.00	$0.00
	Mob / Demob		LUMP	1	$0.00	$0.00
	Contingency		LUMP	1	$0.00	$0.00
	General Structure Maintenance		LUMP	1	$0.00	$0.00
	OTHER			1	$45,090.00	$45,090.00
	OTHER				$0.00	$0.00
	OTHER				$0.00	$0.00
					TOTAL CONSTRUCTION COSTS:	**$45,090.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$78,592.00**

OPERATION AND MAINTENANCE BUDGET 07/01/2006 - 06/30/2007

Highway 384 Hydrologic Restoration / CS-21. / PPL 2

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,119.00	**$5,119.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1		**$0.00**
Operations Contract	LUMP	1	$6,000.00	**$6,000.00**
Construction Oversight	LUMP	1	$7,168.00	**$7,168.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	1	$3,000.00	$3,000.00
FEDERAL SPONSER Admin.	LUMP	1	$1,000.00	$1,000.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$4,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:					
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navagation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	1	$0.00	$0.00
Materials		LUMP	1	$0.00	$0.00
Mob / Demob		LUMP	1	$0.00	$0.00
Contingency		LUMP	1	$0.00	$0.00
General Structure Maintenance		LUMP	1	$0.00	$0.00
OTHER			1	$50,000.00	$50,000.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$50,000.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$72,287.00**

OPERATION AND MAINTENANCE BUDGET 07/01/2007 - 06/30/2008

Highway 384 Hydrologic Restoration / CS-21 / PPL 2

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,288.00	**$5,288.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations Contract	LUMP	1	$6,000.00	**$6,000.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**
ADMINISTRATION				
LDNR / CRD Admin.	LUMP	1	$1,000.00	$1,000.00
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$1,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
	Secondary Monument	EACH	0	$0.00	$0.00
	Staff Gauge / Recorders	EACH	0	$0.00	$0.00
	Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
	TBM Installation	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:						
	Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
	Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
	Navagation Aid		EACH	0	$0.00	$0.00
	Signage		EACH	0	$0.00	$0.00
	General Excavation / Fill		CU YD	0	$0.00	$0.00
	Dredging		CU YD	0	$0.00	$0.00
	Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
	Timber Piles (each or lump sum)			0	$0.00	$0.00
	Timber Members (each or lump sum)			0	$0.00	$0.00
	Hardware		LUMP	1	$0.00	$0.00
	Materials		LUMP	1	$0.00	$0.00
	Mob / Demob		LUMP	1	$0.00	$0.00
	Contingency		LUMP	1	$0.00	$0.00
	General Structure Maintenance		LUMP	1	$0.00	$0.00
	OTHER				$0.00	$0.00
	OTHER				$0.00	$0.00
	OTHER				$0.00	$0.00
					TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$12,288.00**

Appendix C
(Field Inspection Notes)

No inspection was conducted in calendar year 2005 because this project is currently under a maintenance event, therefore no field inspection notes were available.